

PERFORMANCE OF RECOMBINANT INBRED LINES OF BPT5204 X HP14 RICE CROSSES FOR YIELD AND DROUGHT RELATED TRAITS UNDER AEROBIC DROUGHT CONDITION

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ABSTRACT

Rice is the premier food staple of the world especially in the rainfed areas of Asia, where drought is a major production constraint. 281 recombinant inbred lines (RILs) along with two parents and four checks (MAS 946-1, Rasi) were evaluated under aerobic, rainfed and drought conditions to identify superior genotypes. Field evaluation revealed significant difference among the means of different genotypes for all the traits except for test weight under aerobic condition and percentage sterility under low moisture condition during Kharif 2012. The results clearly showed genotype under aerobic condition generally yielded higher estimates of variance for genetic effects than those under moisture stress. However, grain yield traits such as days to flowering, days to physiological maturity, 1000 grain weight and drought traits viz., per cent spikelet fertility, SPAD chlorophyll meter reading had higher estimates of variance under moisture stress condition. This pointed to the fact that correlation studies of relative contributions of various grain yield and drought traits is necessary for effective selection of genotype under both aerobic and moisture stress condition. The RIL No.96, 117, 235, 398, 616, 861, 971, 1201, 2386 and 81 were found to be superior to their parents in terms of their ability to produce higher total tillers, productive tillers, 1000 grain weight and grain yield.

KEYWORDS: Correlation Studies, Estimates of Variance for Genetic Effects, Aerobic Condition

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INTRODUCTION

Rice (*Oryza sativa* L.) is the principle food and energy source for more than half of the world's population. Rice ranks second in cereal production (672 million tonnes) after maize (FAO, 2011). Annually rice is grown in 135 million ha with an annual production of 672 million tonnes (FAO, 2011). In Asia, more than 90 per cent of the world's rice is grown accounting to 35 to 65 per cent of the total energy intake (Khush, 1997). India ranks first in area (44.5 m ha) and second in production (102 mt) among the rice producing countries in the world. However, India ranks 9th in terms of productivity (Anon. 2010).

Rice is cultivated in several ecosystems like upland, rainfed lowland, flood prone and irrigated. Crop frequently faces abiotic stress in all these ecosystems except irrigated ecosystem. Worldwide there is 54 million ha of rainfed lowlands, which contribute 19 per cent and 14 million ha of rainfed uplands, contribute 4 per cent of the world's total rice production (Maclean *et al.*, 2002). Drought during the cropping season directly affects grain yield, particularly at the reproductive stage, which is the most sensitive stage. Worldwide, drought affects approximately 23 million ha of rainfed rice. Among different rainfed regions, eastern India, with around 13.6 million ha of drought-prone area, is the largest in the world.

The annual losses due to drought are estimated to be of 134 kg/ha (9.9 million tons of grains annually) in Asia alone. Drought is hence the most serious constraint that limit rice yields, especially in rainfed ecosystems (Serraj, *et al.* 2009). Recently India has faced drought leads to drastic reduction in total rice production from 99.4 million tonnes in 2008-09 to 89.1 million tonnes in 2009-10 (Anon., 2010). Water scarcity is escalating and irrigation is becoming a costly input. Therefore development of high yielding lines of rice tolerant to severe stress is essential and practical strategy to increase rice production.

With this view in the present study, recombinant inbred lines (RILs) were evaluated under aerobic drought condition to identify high yielding and drought tolerant RILs.

MATERIALS AND METHODS

The experiment was carried out during Kharif (wet) season of 2012 at 'K' block, GKVK, Bangalore, representing the eastern dry zone which is located at the latitude of 12° 58' North; longitude 77° 35' East and altitude of 930 meters above mean sea level. The selected lines were evaluated in a simple lattice design with two replications under aerobic condition and water stress condition, respectively.

Material

Recombinant Inbred Lines (RILs) were developed by Dr. Shailaja Hittalmani and Dr. Hanamareddy Biradar (2004-05) using two diverse parents *viz.*, BPT – 5204 (good grain quality and high yielding ability) crossed with HPR – 14 (Drought tolerance and blast resistance). 1267 segregating lines were developed in F₂ and further in F₃ 3604 lines were generated and forwarded for development of RILs and a subset of 281 RILs lines were used in the present study.

Cultural Operations

Recommended cultural operations and plant protection measures were taken up to ensure uniform and healthy crop stand as per package of practices (www.aerobicrice.org). But the crop was grown by providing irrigation once in three days under aerobic condition Water discharge in liters was measured using water discharge meter and total water discharge during cropping season was recorded.

Moisture Stress Imposition at Reproductive Stage

Moisture stress was induced and irrigation was withheld for 15 days from 90th day to 105th day at reproductive stage under rainout shelter. Soil moisture was recorded in regular interval from first day of stress to 15th day of stress by gravimetric method.

Statistical Analysis

The statistical analysis on the mean values of five randomly selected plants from each of the two replications under aerobic and water stress condition was carried out on individual characters. ANOVA for simple lattice design (Meier, 1954), Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (GCV) (Burton and De Vane, 1953), Heritability (H^2) (Johnson *et al.*, 1955) Genetic advance (GA) (Johnson *et al.*, 1955), correlation coefficient (Al-Jobourie *et al.*, 1958; Sunderaraj *et al.* 1972) and Path coefficient analysis Wright (1921) and Dewey and Lu (1959) was carried out.

RESULTS AND DISCUSSIONS

The analysis of variance for all grain yield and drought related traits showed highly significant genotypes mean sum of squares. The results clearly showed that wide genetic differences for all grain yield and drought traits (Table 1a & 1b). ANOVA for the grain yield traits under both aerobic and moisture stressed condition was significant at 0.001 probabilities, expect for 1000 grain weight under moisture stress.

High GCV and PCV was observed for grain yield related traits *viz.*, total and productive tiller number, 1000 grain weight, harvest index, grain yield per plant and drought related traits *viz.*, panicle exertion, filled spikelets panicle⁻¹, yield day⁻¹ and yield water use efficiency under both control and moisture stress condition. High heritability was evident in plant height at 45 days, days to 50% flowering, days to physiological maturity, total, productive tillers plant⁻¹ and filled spikelets panicle⁻¹. High heritability coupled with high genetic advance was found in final plant height, filled spikelets panicle⁻¹ and yield day⁻¹ under both control and moisture stress condition. High heritability coupled with medium genetic advance was found days to 50% flowering, days to physiological maturity, whereas remaining were shown low level of genetic advance.

Grain yield was found to be positively correlated with total and productive tillers plant⁻¹ and harvest index, panicle length, filled seeds panicle-1, spikelets fertility, yield day⁻¹, yield water use efficiency in both control and moisture stress condition. In control condition with final plant height, panicle exertion and in moisture stress condition with leaf chlorophyll content (SPAD).

Path analysis for grain and drought related traits with grain yield showed that, harvest index, productive tillers plant-1 and final plant height has showed high positive direct effect to grain yield in both control and moisture stress condition, whereas yield day⁻¹ showed positive direct effect under control, yield water use efficiency has shown high negative direct effect in control and high positive direct effect under moisture stress condition.

Based on all yield and drought contributing traits 10 RILs were identified in this experiment *viz.*, 96, 117, 235, 398, 616, 861, 971, 1201, 2386 and 81 (table 5a & 5b) out performed to their parents and checks.

CONCLUSIONS

Based on genetic variability parameters, correlation and path coefficient analysis it was observed that total and productive tillers plant⁻¹ and harvest index, panicle length, filled seeds panicle-1, spikelets fertility, yield day⁻¹, yield water use efficiency were found to be principal traits in selection of high yielding and drought tolerant recombinant inbred lines. Based on grain and drought attributing traits there were 10 RILs were identified as a high yielding and drought tolerant.

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APPENDICES

Table 1a: Analysis of Variance for Grain Yield Related Traits under Aerobic and Moisture Stress Condition in 281 Rice RILs

Source of Variations	DF		Mean Sum of Squares									
			PHT(35D)	PHT(45D)	FPH	DF	DPM	TT	PT	1000GW	HI	GYLD
Replications	1	C	0.42	3.96	2.63	0.04	1.26	29.69	0.01	20.77	6.37	30.68
		S	210.36 ***	27.61	39.39	74.85*	3.99	57.31	0.56	1.32	127.42	300.07
Genotypes (unadjusted)	288	C	50.28 ***	93.06 ***	676.44 ***	130.19 ***	142.35 ***	111.71 ***	47.44 ***	78.59 ***	298.69 ***	342.15 ***
		S	37.73 ***	35.68 ***	637.07 ***	167.97 ***	186.02 ***	53.44 ***	30.99 ***	104.34	97.92 ***	170.09 ***
Blocks within Replicated	32	C	8.23	16.17	60.72	12.09	14.96	24.69	13.85	27.41	192.84	133.46
		S	41.29 ***	52.61 ***	11.01	16.87	24.64	24.57	27.95 ***	46.95	181.56 ***	353.2 ***
Intrablock Error	256	C	15.51	21.48	133.61	23.21	24.35	26.98	17.53	34.40	168.94	148.89
		S	10.32	8.59	11.98	17.06	24.48	20.59	8.07	97.06	46.80	66.77
Coefficient of Variation		C	14.13%	12.22%	10.85%	4.83%	3.81%	20.26%	25.25%	26.82%	25.73%	32.11%
		S	12.26%	7.92%	3.57%	4.32%	3.99%	19.40%	20.85%	42.58%	26.49%	35.47%
C.D.5%		C	7.37	8.96	21.19	8.99	9.37	10.18	8.12	11.38	25.77	23.87
		S	6.59	6.04	6.78	8.13	9.75	9.02	5.81	18.21	14.02	16.80

* Significant @ **P=0.05**; ** Significant @ **P=0.01**; *** Significant @ **P=0.001**.

C: Aerobic condition

S: Moisture stress condition.

PHT (35D) - Plant Height (cm) at 35 days

PHT (45D) - Plant Height (cm) at 45 days

FPH - Final Plant Height (cm)

DF - Days to 50 % flowering

DPM - Days to Physiological maturity

TT - Total Tillers

PT - Productive Tillers.

1000GW - 1000 Grain Weight (g)

HI - Harvest Index (%)

GYLD - Grain Yield Plant⁻¹ (g)

Table 1b: Analysis of Variance for Drought Related Traits under Aerobic and Moisture Stress Condition in 281 Rice RILs

Source of Variations	DF		Mean Sum of Squares							
			PL	PE	FS/S	FMI	%SF	LCC	Y/D	YWUE
Replications	1	C	0.85	0.80	746.80	1.46	39.97	17.99	1801.33	0.18
		S	13.71*	11.23	4473.47	64.44***	522.57	21.35	17149.92	1.90
Genotypes (unadjusted)	288	C	10.14 ***	26.21 ***	3492.25 ***	5.85 ***	147.90 ***	24.70 ***	21988.91 ***	2.19 ***
		S	6.30***	16.51***	2602.07	5.51*	355.82**	34.96***	11537.08	1.38***
Blocks within Replicated	32	C	2.21	4.58	981.91	2.27	23.54	3.97	8765.64	0.88
		S	4.1*	7.21	2331.74	5.90	385.13*	6.79	23659.13***	2.89***
Intrablock Error	256	C	2.69	6.10	947.62	1.99	43.49	6.38	9353.01	0.94
		S	2.61	5.71	2159.24	4.20	247.09	5.11	4485.92	0.54
Coefficient of Variation		C	7.45%	161.94%	20.61%	4.69%	7.62%	5.83%	31.75%	31.76%
		S	8.02%	100.27%	40.91%	7.25%	23.00%	5.83%	35.79%	35.81%
C.D. 5%		C	3.189	4.774	60.739	2.794	12.361	4.805	189.74	1.898
		S	3.246	4.759	91.883	4.098	31.566	4.514	137.7	35.81%

* Significant @ **P=0.05**; ** Significant @ **P=0.01**; *** Significant @ **P=0.001**.

C: Aerobic condition.

S: Moisture stress condition.

PL - Panicle Length (cm).

%SF - Spikelet Fertility (%).

PE - Panicle Exsertion (cm).

SCMR - SPAD Chlorophyll meter reading.

FS/ S - Filled Seeds Panicle⁻¹.

Y/ D - Yield Day-1 (mgd⁻¹).

FMI - Flowering to Maturity Interval (days). **YWUE** - Yield Water Use Efficiency (mgkg⁻¹d⁻¹).

Table 2a: Genetic Variability Parameters for Grain Yield and Its Attributing Traits under Aerobic and Moisture Stress Conditions in 281 Rice RILs

Characters	Vg		Vp		GCV		PCV		H ²		GAM	
	Aerobic	Stress	Aerobic	Stress	Aerobic	Stress	Aerobic	Stress	Aerobic	Stress	Aerobic	Stress
PHT(35D)	17.38	13.71	32.90	24.03	15.72	13.57	21.63	17.96	52.85	57.04	6.24	5.76
PHT(45D)	35.79	13.54	57.27	22.14	16.10	9.51	20.37	12.16	62.49	61.18	9.74	5.93
FPH	271.42	312.55	405.02	324.52	16.62	18.33	20.30	18.68	67.01	96.31	27.78	35.74
DF	53.49	75.45	76.70	92.52	7.75	9.10	9.28	10.07	69.74	81.56	12.58	16.16
DPM	59.00	80.77	83.35	105.25	6.16	7.24	7.32	8.26	70.79	76.75	13.31	16.22
TT	42.37	16.43	69.34	37.01	25.69	28.69	32.87	43.06	61.10	44.38	10.48	5.56
PT	14.96	11.46	32.48	19.53	23.92	14.35	35.25	18.73	46.04	58.68	5.41	5.34
1000GW	22.10	3.64	56.49	100.70	20.96	9.42	33.51	49.56	39.12	3.62	6.06	0.75
HI	64.88	25.56	233.81	72.36	24.13	18.81	45.81	31.65	27.75	35.32	8.74	6.19
GYLD	96.63	51.66	245.52	118.43	25.99	29.88	41.42	45.24	39.36	43.62	12.70	9.78

Vg: Genotypic variance.

Vp: Phenotypic variance.

GCV: Genotypic coefficient of variation.

PCV: Phenotypic coefficient of variation.

H²: Broad sense heritability.

GAM: Genetic advance as percent Mean.

PHT (35D) - Plant Height (cm) at 35 days.**PHT (45D)** - Plant Height (cm) at 45 days.**FPH** - Final Plant Height (cm).**DF** - Days to 50 % flowering.**DPM** - Days to Physiological maturity.**TT** - Total Tillers.**PT** - Productive Tillers.**1000GW** - 1000 Grain Weight (g).**HI** - Harvest Index (%).**GYLD** - Grain Yield Plant⁻¹ (g).**Table 2b: Genetic Variability Parameters for Drought Related Traits under Aerobic and Moisture Stress Conditions in 281 rice RILs**

Characters	Vg		Vp		GCV		PCV		H ²		GAM	
	Control	Stress	Control	Stress	Control	Stress	Control	Stress	Control	Stress	Control	Stress
PL	3.73	1.84	6.41	4.46	8.89	6.61	11.66	10.27	58.12	41.39	3.03	1.80
PE	10.05	5.40	16.16	11.11	209.52	96.44	265.61	138.31	62.23	48.62	5.15	3.34
FS/S	1272.31	221.41	2219.94	2380.65	24.47	13.09	32.32	42.91	57.31	9.30	55.63	9.35
FMI	1.93	0.66	3.92	4.85	4.59	2.82	6.53	7.67	49.31	13.54	2.01	0.61
%SF	52.20	54.37	95.70	301.45	8.80	36.03	11.91	84.84	54.55	18.03	10.99	6.45
LCC	9.16	14.92	15.54	20.04	7.26	18.59	9.46	21.54	58.92	74.48	4.79	6.87
Y/D	6317.95	3525.58	15670.96	8011.50	26.10	30.40	41.10	45.82	40.32	44.01	103.97	81.14
YWUE	0.63	0.42	1.56	0.96	26.24	30.07	41.42	45.60	40.14	43.48	1.03	0.88

Vg: Genotypic variance.**Vp:** Phenotypic variance.**GCV:** Genotypic coefficient of variation.**PCV:** Phenotypic coefficient of variation.**H²:** Broad sense heritability.**GAM:** Genetic advance as percent Mean.**PL** - Panicle Length (cm).**PE** - Panicle Exsertion (cm).**FS/ S** - Filled Seeds Panicle⁻¹.**FMI** - Flowering to Maturity Interval (days).**%SF** - Spikelet Fertility (%).**SCMR** - SPAD Chlorophyll meter reading.**Y/ D** - Yield Day-1 (mgd⁻¹).**YWUE** - Yield Water Use Efficiency (mgkg⁻¹d⁻¹).**Table 3a: Phenotypical Correlation for Grain Yield Related Traits under Aerobic and Moisture Stress Conditions in 281 Rice RILs**

Characters	PHT(35D)	PHT(45D)	FPH	DF	DPM	TT	PT	1000GW	HI	GYLD
PHT(35D)	C ₀	l ₀	0.69***	0.52***	0.01	0.01	-0.17	-0.12	-0.04	0.01
	S ₀	l ₀	0.90***	0.46***	-0.15***	-0.16***	-0.05	-0.08*	0.084*	-0.09*
PHT(45D)	C ₀	l ₀	0.55***	-0.06	-0.08	-0.20	-0.15	-0.03	-0.04	0.04
	S ₀	l ₀	0.45***	-0.12**	-0.13**	-0.02	-0.04	0.057	-0.08*	0.001
FPH	C ₀	l ₀	l ₀	-0.01	-0.02	-0.18	-0.21	-0.025	0.13**	0.20***
	S ₀	l ₀	l ₀	-0.17***	-0.17***	-0.20***	-0.24***	0.03	-0.09*	-0.01
DF	C ₀	l ₀	l ₀	l ₀	0.97***	0.12**	0.17***	-0.03	-0.14	0.03
	S ₀	l ₀	l ₀	l ₀	0.96***	0.13**	0.16***	-0.03	-0.23***	-0.05
DPM	C ₀	l ₀	l ₀	l ₀	l ₀	0.12**	0.18***	-0.02	-0.13	0.04
	S ₀	l ₀	l ₀	l ₀	l ₀	0.14***	0.17***	-0.04	-0.22***	-0.04
TT	C ₀	l ₀	l ₀	l ₀	l ₀	l ₀	0.39***	-0.02	-0.01	0.30***
	S ₀	l ₀	l ₀	l ₀	l ₀	l ₀	0.73***	0.02	-0.05	0.28***
PT	C ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	-0.07	0.08	0.58***
	S ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	0.01	0.11**	0.48***
1000GW	C ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	0.10*	0.09
	S ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	0.01	0.04
HI	C ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	0.51***
	S ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	l ₀	0.69***

* Significant @ **P=0.05**; ** Significant @ **P=0.01**; *** Significant @ **P=0.001**.

C: Aerobic condition.

S: Moisture stress condition.

PHT (35D) - Plant Height (cm) at 35 days.

TT - Total Tillers.

PHT (45D) - Plant Height (cm) at 45 days.

PT - Productive Tillers.

FPH - Final Plant Height (cm).

1000GW - 1000 Grain Weight (g).

DF - Days to 50 % flowering.

HI - Harvest Index (%).

DPM - Days to Physiological maturity.

GYLD - Grain Yield Plant⁻¹ (g).

Table 3b: Phenotypical Correlation for Drought Related Traits under Aerobic and Moisture Stress Conditions in 281 Rice RILs

Characters	PL	PE	Fs/p	FMI	%SF	LCC	Y/D	YWUE	GYLD
PL	C	1	0.33***	0.03	0.12**	-0.01	0.20***	0.20***	0.22***
	S	1	0.12**	0.22***	0.01	0.10**	0.07	0.21***	0.21***
PE	C	1	0.32***	-0.04	0.30***	-0.09*	0.21***	0.21***	0.19***
	S	1	0.03	-0.06	0.19***	-0.06	0.0001	0.04	0.01
Fs/p	C	1	1	-0.01	0.42***	-0.06	0.30***	0.30***	0.30***
	S	1	1	0.07	0.59***	0.02	0.18***	0.35***	0.35***
FMI	C	1	1	1	-0.05	0.04	-0.02	-0.02	0.02
	S	1	1	1	0.01	0.05	-0.09*	-0.01	0.051
%SF	C	1	1	1	1	-0.003	0.19***	0.19***	0.19***
	S	1	1	1	1	0.04	0.15***	0.32***	0.31***
SPAD	C	1	1	1	1	1	0.03	0.03	0.04
	S	1	1	1	1	1	0.01	0.089*	0.10*
Y/D	C	1	1	1	1	1	1	1.00***	0.98***
	S	1	1	1	1	1	1	0.46***	0.45***
YWUE	C	1	1	1	1	1	1	1	0.98***
	S	1	1	1	1	1	1	1	0.98***

* Significant @ **P=0.05**; ** Significant @ **P=0.01**; *** Significant @ **P=0.001**.

C: Aerobic condition.

S: Moisture stress condition.

PL - Panicle Length (cm).

%SF - Spikelet Fertility (%).

PE - Panicle Exsertion (cm).

SCMR - SPAD Chlorophyll meter reading.

FS/ S - Filled Seeds Panicle⁻¹.

Y/ D - Yield Day-1 (mgd⁻¹).

FMI - Flowering to Maturity Interval (days).

YWUE - Yield Water Use Efficiency (mgkg⁻¹d⁻¹).

Table 4a: Direct and Indirect Effect of Quantitative Traits on Grain Yields under Aerobic and Moisture Stress Conditions in 281 Rice RILs

Characters	PHT(35D)	PHT(45D)	FPH	DF	DPM	TT	PT	1000GW	HI	Correlation with GYLD
PHT(35D)	C	0.05	0.03	0.03	0.00	0.00	-0.01	-0.01	0.00	0.09
	S	0.06	0.06	0.03	-0.01	-0.01	0.00	-0.01	0.01	-0.01
PHT(45D)	C	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.04
	S	-0.04	-0.04	-0.02	0.01	0.01	0.00	0.00	0.00	0.00
FPH	C	0.15	0.16	0.28	0.00	-0.01	-0.05	-0.06	-0.01	0.20
	S	0.07	0.07	0.15	-0.03	-0.03	-0.03	-0.04	0.01	-0.02
DF	C	0.00	0.00	0.00	-0.04	-0.04	-0.01	-0.01	0.00	0.04
	S	-0.01	-0.01	-0.01	0.08	0.08	0.01	0.01	-0.02	-0.06
DPM	C	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.04
	S	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00	0.00	-0.05
TT	C	-0.02	-0.03	-0.03	0.02	0.02	0.14	0.06	0.00	0.30
	S	0.00	0.00	-0.01	0.01	0.01	0.05	0.04	0.00	0.28
PT	C	-0.07	-0.09	-0.12	0.10	0.10	0.22	0.57	-0.04	0.58
	S	-0.03	-0.02	-0.10	0.07	0.07	0.30	0.40	0.00	0.49
1000GW	C	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.10	0.10
	S	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.05
HI	C	0.01	-0.02	0.06	-0.06	-0.06	0.00	0.03	0.04	0.52
	S	-0.06	-0.06	-0.06	-0.16	-0.15	-0.04	0.08	0.01	0.69

RESIDUAL EFFECT: C = 0.58; S = 0.57.

C: Aerobic condition.

S: Moisture stress condition.

PHT (35D) - Plant Height (cm) at 35 days.

PHT (45D) - Plant Height (cm) at 45 days.

FPH - Final Plant Height (cm).

DF - Days to 50 % flowering.

DPM - Days to Physiological maturity.

TT - Total Tillers.

PT - Productive Tillers.

1000GW - 1000 Grain Weight (g).

HI - Harvest Index (%).

GYLD - Grain Yield Plant⁻¹ (g).

Table 4b: Direct and Indirect Effect of Drought Related Traits on Grain Yield under Aerobic and Moisture Stress Conditions in 281 Rice RILs

Characters		PL ₀	PE ₀	Fs/p ₀	FMI ₀	%SF ₀	LCC ₀	Y/D ₀	YWUE ₀	Correlation' with-GYLD ₀
PL ₀	C ₀	0.03 ₀	0.01 ₀	0.01 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.01 ₀	0.01 ₀	0.22 ₀
	S ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.21 ₀
PE ₀	C ₀	-0.01 ₀	-0.02 ₀	-0.01 ₀	0.00 ₀	-0.01 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.20 ₀
	S ₀	0.00 ₀	-0.02 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.02 ₀
FS/S ₀	C ₀	0.00 ₀	0.00 ₀	0.01 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.31 ₀
	S ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.36 ₀
FMI ₀	C ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.05 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.02 ₀
	S ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.06 ₀	0.00 ₀	0.00 ₀	-0.01 ₀	0.00 ₀	0.05 ₀
%SF ₀	C ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.01 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.19 ₀
	S ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.31 ₀
SPAD ₀	C ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.04 ₀
	S ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.02 ₀	0.00 ₀	0.00 ₀	0.11 ₀
Y/D ₀	C ₀	0.55 ₀	0.58 ₀	0.83 ₀	-0.08 ₀	0.54 ₀	0.10 ₀	0.74 ₀	0.74 ₀	0.98 ₀
	S ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.45 ₀
YWUE ₀	C ₀	-0.35 ₀	-0.37 ₀	-0.53 ₀	0.05 ₀	-0.34 ₀	-0.07 ₀	-1.76 ₀	-0.76 ₀	0.98 ₀
	S ₀	0.21 ₀	0.04 ₀	0.35 ₀	-0.01 ₀	0.32 ₀	0.08 ₀	0.46 ₀	0.98 ₀	0.98 ₀

RESIDUAL EFFECT: C = 0.17; S = 0.17.

C: Aerobic condition.

S: Moisture stress condition.

PL - Panicle Length (cm).

PE - Panicle Exsertion (cm).

FS/ S - Filled Seeds Panicle⁻¹.

FMI - Flowering to Maturity Interval (days).

%SF - Spikelet Fertility (%).

SCMR - SPAD Chlorophyll meter reading.

Y/ D - Yield Day⁻¹ (mgd⁻¹).

YWUE - Yield Water Use Efficiency (mgkg⁻¹d⁻¹).

Table 5a: Performance of Top Ranking Rice RILs, Parents and Checks for Grain Yield and its Component Traits under Aerobic and Moisture Stress Condition

Characters		Parents				Checks		RIL NO.										CD between RILs
		BPT5204	HPR 14	MAS 946-1	Rasi	96	117	235	398	616	861	971	1201	2386	81			
PHT(35D)	C	20.40	37.00	28.00	33.20	19.75	30.50	26.75	25.08	23.33	23.92	23.25	31.67	30.08	39.50	5.34		
	S	18.20	31.60	26.60	26.60	27.70	29.25	31.30	31.40	27.60	26.10	22.70	27.50	31.20	32.45	5.76		
PHT(45D)	C	27.20	48.00	29.80	43.20	39.42	40.50	44.67	38.00	30.50	36.08	26.33	43.75	44.42	53.00	10.07		
	S	32.20	41.70	37.20	37.60	44.40	44.13	42.20	42.40	38.77	37.00	35.10	38.30	43.80	43.03	4.22		
FPH	C	63.00	112.00	65.40	83.20	106.50	106.00	113.25	106.25	65.00	110.25	81.42	115.58	105.75	103.50	14.26		
	S	55.90	89.40	65.20	78.70	108.50	109.95	122.20	95.40	70.93	101.40	104.00	102.20	95.90	104.60	3.27		
DF	C	112	96	100.00	88.00	92	89	87	96	96	88	98	97	88	88	5.22		
	S	116	102	102.00	88.50	89	88	87	95	102	88	93	106	89	89	2.08		
DPM	C	145	126	129.00	120.00	119	118	115	126	126	117	127	130	120	119	5.8		
	S	144	132	132.00	115.00	117	118	114	109	130	117	122	135	117	118	11.93		
TT	C	36	20	35	26	34	23	15	31	44	35	31	27	30	25	5.53		
	S	33	23	27	25	35	32	21	27	38	24	27	25	20	17	8.71		
PT	C	13	16	27	23	24	20	13	19	37	14	15	12	19	21	6.1		
	S	14	14	17	17	17	18	12	14	19	14	18	16	18	9	5.24		
1000GW	C	28.10	13.89	20.82	25.74	31.26	22.12	30.98	24.83	25.91	32.73	20.21	21.78	23.65	20.92	12.08		
	S	11.83	19.27	21.31	20.30	13.11	17.98	21.09	21.95	25.09	15.62	17.93	31.55	30.27	16.68	6.75		
HI	C	38.04	25.66	35.33	38.21	48.93	44.20	65.90	60.63	54.02	58.17	62.60	60.77	57.66	48.60	19.84		
	S	6.32	13.57	15.29	31.41	30.10	28.90	29.12	29.42	33.11	36.60	36.97	29.12	27.40	26.84	7.71		
GYLD	C	27.42	22.72	40.16	42.70	43.23	56.33	49.48	52.95	82.88	42.58	43.38	47.85	58.77	44.67	27.33		
	S	3.71	9.71	11.77	28.51	38.92	32.79	33.81	32.60	35.91	34.28	43.47	40.56	27.31	14.37	17.94		

C: Aerobic condition. **S:** Moisture stress condition

PHT (35D) - Plant Height (cm) at 35 days.

PHT (45D) - Plant Height (cm) at 45 days.

FPH - Final Plant Height (cm).

DF - Days to 50 % flowering.

DPM - Days to Physiological maturity.

TT - Total Tillers.

PT - Productive Tillers.

1000GW - 1000 Grain Weight (g).

HI - Harvest Index (%).

GYLD - Grain Yield Plant⁻¹ (g).

Table 5b: Performance of Top Ranking Rice RILs, Parents and Checks for Drought Related Traits under Aerobic and Moisture Stress Condition

Characters		Parents		Checks		RIL NO.										CD between RIL
		BPT5204	HPR 14	MAS 946-1	Rasi	96	117	235	398	616	861	971	1201	2386	81	
PL	C	17.60	20.00	22.30	22.40	22.42	19.50	23.50	22.75	19.75	22.08	23.83	25.58	22.83	22.50	2.51
	S	16.53	19.70	22.37	21.00	22.15	19.50	21.60	24.58	19.90	20.70	22.70	22.59	20.90	22.50	1.05
PE	C	-7.80	3.30	-1.00	1.40	2.00	5.58	4.00	-0.58	-3.33	4.79	0.17	2.17	-1.83	0.50	4.45
	S	-8.08	-0.80	-5.15	-1.70	-4.75	0.19	0.25	-6.04	-7.40	1.90	-1.85	-4.94	-2.05	-1.85	3.97
Fs/p	C	80.00	163.00	180.00	122.00	178.50	239.50	147.50	131.50	107.00	127.00	144.00	208.00	126.50	138.00	55.36
	S	48.00	56.00	44.00	166.00	69.00	141.00	153.50	177.50	128.50	161.50	174.00	129.00	91.00	99.50	97.45
FMI	C	33	30	29.00	32.00	28	29	28	30	30	29	29	33	32	31	1.97
	S	28	30	30.00	26.00	28	30	27	30	28	29	30	29	28	29	2.02
%SF	C	83.33	96.45	92.31	89.05	90.53	85.40	93.07	71.03	78.21	85.69	75.86	82.92	83.29	79.00	10.53
	S	33.03	59.55	36.00	84.86	73.45	69.44	81.17	52.43	73.59	90.47	65.40	55.51	68.69	72.51	31.58
SCMR	C	48.50	40.50	40.00	50.00	48.83	40.90	46.25	46.20	44.65	39.00	41.50	42.40	40.90	42.60	4.66
	S	43.03	35.00	35.20	44.50	37.14	40.07	40.02	43.05	34.40	41.30	44.80	33.70	37.55	46.45	7.32
Y/D	C	189.09	180.35	381.05	570.93	364.14	477.70	430.96	421.11	661.14	362.34	349.16	368.82	491.35	376.99	226.91
	S	25.57	73.59	89.13	373.78	332.66	279.61	296.67	302.51	277.08	295.79	356.37	300.43	234.58	122.61	72.17
YWUE	C	1.87	1.79	2.78	3.63	3.64	4.78	4.31	4.21	6.61	3.62	3.49	3.69	4.91	3.77	2.27
	S	0.28	0.81	0.98	2.12	3.66	3.07	3.26	3.32	3.04	3.25	3.92	3.30	2.58	1.35	0.794

C: Aerobic condition. **S:** Moisture stress condition.

PL - Panicle Length (cm).

PE - Panicle Exsertion (cm).

FS/ S - Filled Seeds Panicle⁻¹.

FMI - Flowering to Maturity Interval (days).

%SF - Spikelet Fertility (%).

SCMR - SPAD Chlorophyll meter reading.

Y/ D - Yield Day-1 (mgd⁻¹).

YWUE - Yield Water Use Efficiency (mgkg⁻¹d⁻¹).

